VOC Emission Calculations

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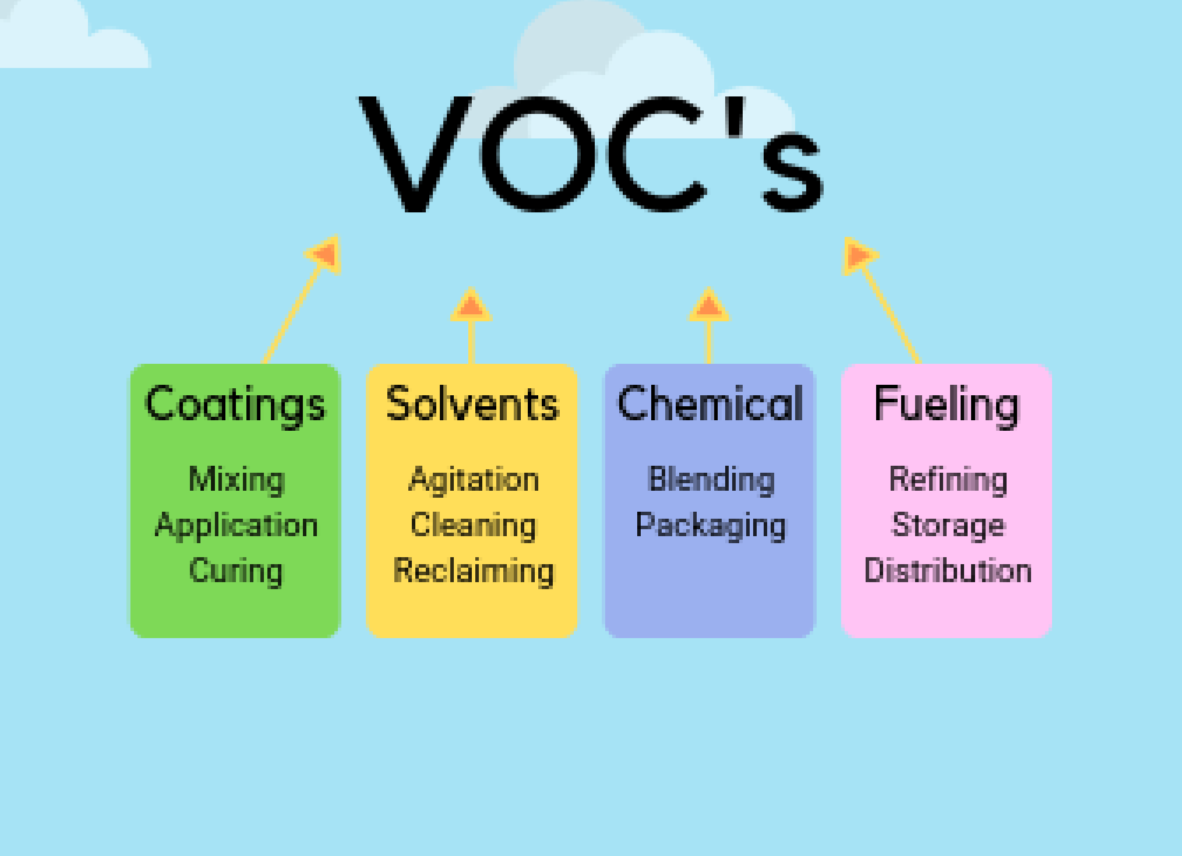
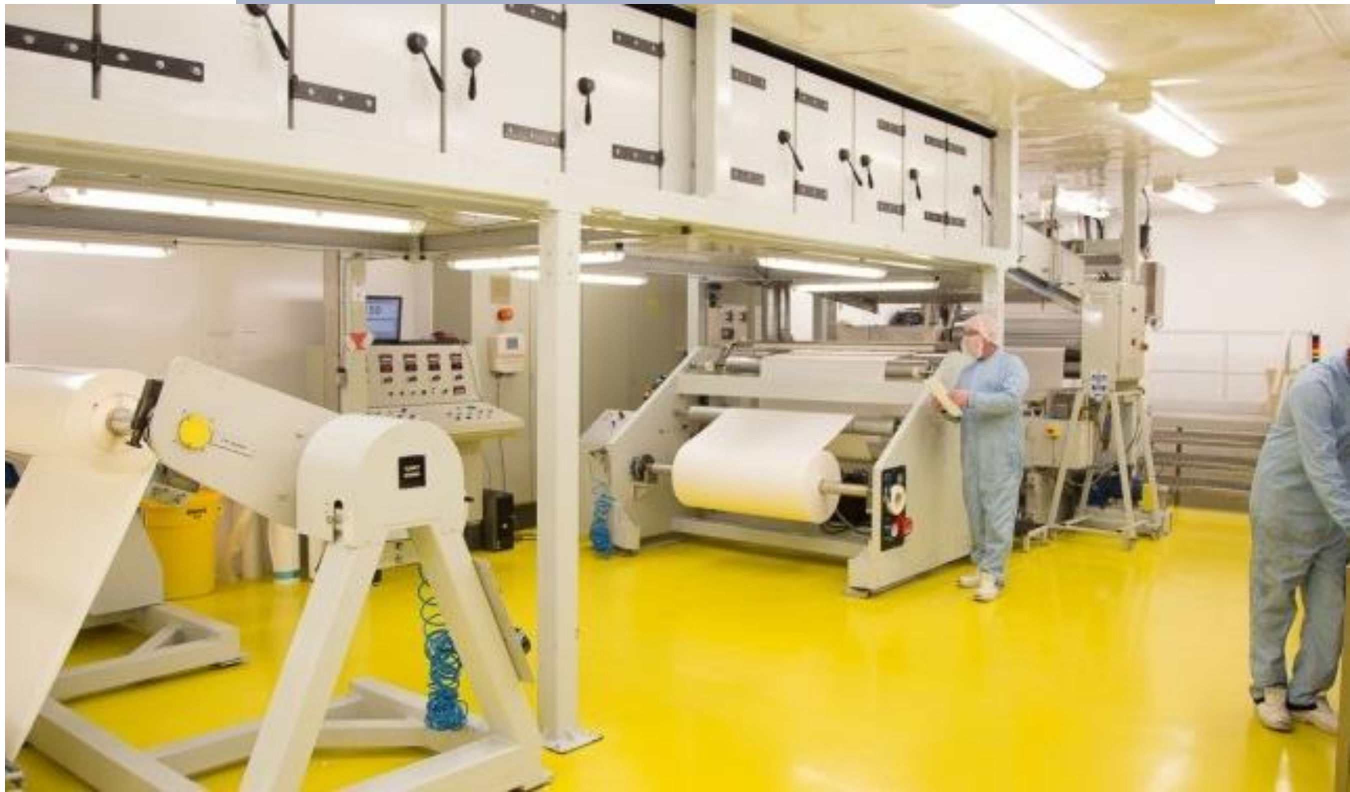
\begin{gathered}
\mathcal{L}_{SM} = -\tfrac{1}{2}\partial_\nu g^a_\mu \partial_\nu g^a_\mu - g_s f^{abc}\partial_\mu g^a_\nu g^b_\mu g^c_\nu - \tfrac{1}{4}g_s^2 f^{abc} f^{ade} g^b_\mu g^c_\nu g^d_\mu g^e_\nu - \partial_\nu W^+_\mu \partial_\nu W^-_\mu - \\
M^2 W^+_\mu W^-_\mu - \tfrac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \tfrac{1}{2c_w^2} M^2 Z^0_\mu Z^0_\mu - \tfrac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - igc_w(\partial_\nu Z^0_\mu (W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - \\
Z^0_\nu (W^+_\mu \partial_\nu W^-_\mu - W^-_\mu \partial_\nu W^+_\mu) + Z^0_\mu (W^+_\nu \partial_\nu W^-_\mu - W^-_\nu \partial_\nu W^+_\mu)) - igs_w(\partial_\nu A_\mu (W^+_\mu W^-_\nu - \\
W^+_\nu W^-_\mu) - A_\nu (W^+_\mu \partial_\nu W^-_\mu - W^-_\mu \partial_\nu W^+_\mu) + A_\mu (W^+_\nu \partial_\nu W^-_\mu - W^-_\nu \partial_\nu W^+_\mu)) - \\
\tfrac{1}{2}g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu + \tfrac{1}{2}g^2 W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2 c_w^2 (Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) + \\
g^2 s_w^2 (A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2 s_w c_w (A_\mu Z^0_\nu (W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - \\
2A_\mu Z^0_\mu W^+_\nu W^-_\nu) - \tfrac{1}{2}\partial_\mu H \partial_\mu H - 2M^2 \alpha_h H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - \tfrac{1}{2}\partial_\mu \phi^0 \partial_\mu \phi^0 - \\
\beta_h \left(\tfrac{2M^2}{g^2} + \tfrac{2M}{g}H + \tfrac{1}{2}(H^2 + \phi^0\phi^0 + 2\phi^+\phi^-)\right) + \tfrac{2M^4}{g^2}\alpha_h - g\alpha_h M \left(H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-\right) - \\
\tfrac{1}{8}g^2 \alpha_h \left(H^4 + (\phi^0)^4 + 4(\phi^+\phi^-)^2 + 4(\phi^0)^2\phi^+\phi^- + 4H^2\phi^+\phi^- + 2(\phi^0)^2 H^2\right) - gMW^+_\mu W^-_\mu H - \\
\tfrac{1}{2}g\tfrac{M}{c_w^2} Z^0_\mu Z^0_\mu H - \tfrac{1}{2}ig \left(W^+_\mu (\phi^0 \partial_\mu \phi^- - \phi^- \partial_\mu \phi^0) - W^-_\mu (\phi^0 \partial_\mu \phi^+ - \phi^+ \partial_\mu \phi^0)\right) + \\
\tfrac{1}{2}g \left(W^+_\mu (H\partial_\mu \phi^- - \phi^- \partial_\mu H) + W^-_\mu (H\partial_\mu \phi^+ - \phi^+ \partial_\mu H)\right) + \tfrac{1}{2}g\tfrac{1}{c_w}(Z^0_\mu (H\partial_\mu \phi^0 - \phi^0 \partial_\mu H) + \\
M\,(\tfrac{1}{c_w} Z^0_\mu \partial_\mu \phi^0 + W^+_\mu \partial_\mu \phi^- + W^-_\mu \partial_\mu \phi^+) - ig\tfrac{s_w^2}{c_w} M Z^0_\mu (W^+_\mu \phi^- - W^-_\mu \phi^+) + igs_w M A_\mu (W^+_\mu \phi^- - \\
W^-_\mu \phi^+) - ig\tfrac{1-2c_w^2}{2c_w} Z^0_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) + igs_w A_\mu (\phi^+ \partial_\mu \phi^- - \phi^- \partial_\mu \phi^+) - \\
\tfrac{1}{4}g^2 W^+_\mu W^-_\mu \left(H^2 + (\phi^0)^2 + 2\phi^+\phi^-\right) - \tfrac{1}{8}g^2 \tfrac{1}{c_w^2} Z^0_\mu Z^0_\mu \left(H^2 + (\phi^0)^2 + 2(2s_w^2 - 1)^2 \phi^+\phi^-\right) - \\
\tfrac{1}{2}g^2 \tfrac{s_w^2}{c_w} Z^0_\mu \phi^0 (W^+_\mu \phi^- + W^-_\mu \phi^+) - \tfrac{1}{2}ig^2 \tfrac{s_w^2}{c_w} Z^0_\mu H (W^+_\mu \phi^- - W^-_\mu \phi^+) + \tfrac{1}{2}g^2 s_w A_\mu \phi^0 (W^+_\mu \phi^- + \\
W^-_\mu \phi^+) + \tfrac{1}{2}ig^2 s_w A_\mu H (W^+_\mu \phi^- - W^-_\mu \phi^+) - g^2 \tfrac{s_w}{c_w}(2c_w^2 - 1) Z^0_\mu A_\mu \phi^+\phi^- - g^2 s_w^2 A_\mu A_\mu \phi^+\phi^- + \\
\tfrac{1}{2}ig_s \lambda^a_{ij} (\bar{q}^\sigma_i \gamma^\mu q^\sigma_j) g^a_\mu - \bar{e}^\lambda (\gamma\partial + m^\lambda_e) e^\lambda - \bar{\nu}^\lambda (\gamma\partial + m^\lambda_\nu) \nu^\lambda - \bar{u}^\lambda_j (\gamma\partial + m^\lambda_u) u^\lambda_j - \bar{d}^\lambda_j (\gamma\partial + m^\lambda_d) d^\lambda_j + \\
igs_w A_\mu \left(-(\bar{e}^\lambda \gamma^\mu e^\lambda) + \tfrac{2}{3}(\bar{u}^\lambda_j \gamma^\mu u^\lambda_j) - \tfrac{1}{3}(\bar{d}^\lambda_j \gamma^\mu d^\lambda_j)\right) + \tfrac{ig}{4c_w} Z^0_\mu \{(\bar{\nu}^\lambda \gamma^\mu (1+\gamma^5) \nu^\lambda) + (\bar{e}^\lambda \gamma^\mu (4s_w^2 - \\
1 - \gamma^5) e^\lambda) + (\bar{d}^\lambda_j \gamma^\mu (\tfrac{4}{3}s_w^2 - 1 - \gamma^5) d^\lambda_j) + (\bar{u}^\lambda_j \gamma^\mu (1 - \tfrac{8}{3}s_w^2 + \gamma^5) u^\lambda_j)\} + \\
\tfrac{ig}{2\sqrt{2}} W^+_\mu \left((\bar{\nu}^\lambda \gamma^\mu (1+\gamma^5) {U^{lep}}_{\lambda\kappa} e^\kappa) + (\bar{u}^\lambda_j \gamma^\mu (1+\gamma^5) C_{\lambda\kappa} d^\kappa_j)\right) + \\
\tfrac{ig}{2\sqrt{2}} W^-_\mu \left((\bar{e}^\kappa {U^{lep}}^\dagger_{\kappa\lambda} \gamma^\mu (1+\gamma^5) \nu^\lambda) + (\bar{d}^\kappa_j C^\dagger_{\kappa\lambda} \gamma^\mu (1+\gamma^5) u^\lambda_j)\right) + \\
\tfrac{ig}{2M\sqrt{2}} \phi^+ \left(-m^\kappa_e (\bar{\nu}^\lambda {U^{lep}}_{\lambda\kappa} (1-\gamma^5) e^\kappa) + m^\lambda_\nu (\bar{\nu}^\lambda {U^{lep}}_{\lambda\kappa} (1+\gamma^5) e^\kappa\right) + \\
\tfrac{ig}{2M\sqrt{2}} \phi^- \left(m^\lambda_e (\bar{e}^\lambda {U^{lep}}^\dagger_{\lambda\kappa} (1+\gamma^5) \nu^\kappa) - m^\kappa_\nu (\bar{e}^\lambda {U^{lep}}^\dagger_{\lambda\kappa} (1-\gamma^5) \nu^\kappa\right) - \tfrac{g}{2}\tfrac{m^\lambda_\nu}{M} H (\bar{\nu}^\lambda \nu^\lambda) - \\
\tfrac{g}{2}\tfrac{m^\lambda_e}{M} H (\bar{e}^\lambda e^\lambda) + \tfrac{ig}{2}\tfrac{m^\lambda_\nu}{M} \phi^0 (\bar{\nu}^\lambda \gamma^5 \nu^\lambda) - \tfrac{ig}{2}\tfrac{m^\lambda_e}{M} \phi^0 (\bar{e}^\lambda \gamma^5 e^\lambda) - \tfrac{1}{4}\bar{\nu}_\lambda\, M^R_{\lambda\kappa} (1-\gamma_5) \hat{\nu}_\kappa - \\
\tfrac{1}{4}\bar{\nu}_\lambda\, M^R_{\lambda\kappa} (1-\gamma_5) \hat{\nu}_\kappa + \tfrac{ig}{2M\sqrt{2}} \phi^+ \left(-m^\kappa_d (\bar{u}^\lambda_j C_{\lambda\kappa} (1-\gamma^5) d^\kappa_j) + m^\lambda_u (\bar{u}^\lambda_j C_{\lambda\kappa} (1+\gamma^5) d^\kappa_j\right) + \\
\tfrac{ig}{2M\sqrt{2}} \phi^- \left(m^\lambda_d (\bar{d}^\lambda_j C^\dagger_{\lambda\kappa} (1+\gamma^5) u^\kappa_j) - m^\kappa_u (\bar{d}^\lambda_j C^\dagger_{\lambda\kappa} (1-\gamma^5) u^\kappa_j\right) - \tfrac{g}{2}\tfrac{m^\lambda_u}{M} H (\bar{u}^\lambda_j u^\lambda_j) - \tfrac{g}{2}\tfrac{m^\lambda_d}{M} H (\bar{d}^\lambda_j d^\lambda_j) + \\
\tfrac{ig}{2}\tfrac{m^\lambda_u}{M} \phi^0 (\bar{u}^\lambda_j \gamma^5 u^\lambda_j) - \tfrac{ig}{2}\tfrac{m^\lambda_d}{M} \phi^0 (\bar{d}^\lambda_j \gamma^5 d^\lambda_j)
\end{gathered}
$$

Emissions General Formula

Activity × Emission Factor × Control = <u>Emissions</u>


VOC's
Coatings
Mixing
Application
Curing
Solvents
Agitation
Cleaning
Reclaiming
Chemical
Blending
Packaging
Fueling
Refining
Storage
Distribution



Mass Balance Method

What do I need?

- List of the materials used and/or applied (Maybe SDS)
- Actual Annual Usage
- VOC Content by weight % or lbs/gal
- Control Efficiency

Different Equations Depending on Units

Pounds	Amount of Material Used (lb)	×	%VOC in the Material	=	**VOC Emisssions in lb**
Gallons	Amount of Material Used (gal)	×	Lb/gal of VOC in the Material	=	**VOC Emisssions in lb**

Incorporating a Control Device

VOC Emission in lb × (1 - % Control Efficiency) = **After Control VOC Emission in lb**

Emissions General Formula

Activity × Emission Factor × Control = Emissions

EXAMPLE A: usage in pounds and VOC content in %

Material	Lb used	% VOC in Material	Emission(lb)	Control Efficiency (%)	After control Emission (lb)
CoatingWhite	500	55	275	95	13.75
CoatingBlack	200	45	90	95	4.50
TOTAL			365		18.25

Pounds of material used per year X VOC content (% by wt) = Pounds of VOC emitted per year

EXAMPLE B: usage in gallons and VOC content in lb/gal

Material	Gal used	Lb/gal VOC in Material	Emission(lb)	Control Efficiency (%)	After control Emission (lb)
CoatingBlue	60	5.75	345.60	95	17.28
Coating Yellow	30	3.25	97.50	95	4.88
TOTAL			443.10		22.16

Gallons of material used per year X VOC content (lb/gal) = Pounds of VOC emitted per year

Safety Data Sheet

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical States:	[ ] Gas [X] Liquid [ ] Solid
Appearance and Odor:	Water White / Free and Clear
Melting Point:	No data.
Boiling Point:	318.00 F - 385.00 F
Autoignition Pt:	No data.
Flash Pt:	> 100.00 F
Explosive Limits:	LEL: 0.5 UEL: 6
Specific Gravity (Water = 1):	0.78
Vapor Pressure (vs. Air or mm Hg):	0.3 MM HG at 68.0 F
Vapor Density (vs. Air = 1):	5 Air = 1
Evaporation Rate:	No data.
Solubility in Water:	No data.
Solubility Notes:	Very slightly soluble in cold water.
Percent Volatile:	100.0 % by weight.
VOC / Volume:	778.0000 G/L

EXAMPLE C: conversions needed for VOC content

Material	VOC in Material	Density or Specific Gravity (SG)	Convert to	VOC content to be used in calculation
CoatingGreen[1]	4.5 lb/gal	Density = 9.4 lb/gal	%	48 %
CoatingGreen[2]	48 %	Density = 9.4 lb/gal	lb/gal	4.5 lb/gal
CoatingGreen[3]	48 %	SG = 1.13	lb/gal	4.5 lb/gal

[1]VOC content given in lb/gal ÷ Density of material (lb/gal) = VOC content in %

[2]VOC content given in % X Density of material (lb/gal) = VOC content in lb/gal

[3]Specific gravity is the ratio of the density of a compound to the density of water, which is 8.34 lbs/gal.

VOC content given in % X SG X 8.34 = VOC content in lb/gal

ANNUAL VOC, TOXIC AND HAZARDOUS AIR POLLUTANT EMISSION CALCULATOR

Mass Balance Method (Rev. 03/2015)

(User INPUT = Values in Red)

Name of Material Used or Applied and TAP/HAP Constituents	TAP and/or HAP?		Annual Usage		VOC/HAP/TAP Content	Unit (wt.% or lb/gal)	Uncontrolled Emissions		Control Eff.	Controlled Emissions	
			Actual (Unit/yr)	Unit (lb or gal)			Actual lb/yr	Actual tons/yr	(%)	Actual lb/yr	Actual tons/yr
Reference for Equations & Notes:			**a, (1)**	**b, (2)**	**c**	**d, (2)**	**e**	**f**	**g, (3)**	**h, (4)**	**i**
Material X			*20,000*	*gal*							
VOC					*4*	*lb/gal*	*80000*	*40*	*95*	*4000*	*2*
Benzene	*T, H*				*1*	*lb/gal*	*20000*	*10*	*95*	*1000*	*0.5*
Xylene	*T,H*				*0.5*	*lb/gal*	*10000*	*5*	*95*	*500*	*0.25*
Material Y			*5,000*	*lb*							
VOC					*20*	*%*	*1000*	*0.5*	*90*	*100*	*0.05*
Xylene	*T,H*				*10*	*%*	*500*	*0.25*	*90*	*50*	*0.025*
Total VOC							***80,000***	***40.5***		***4100***	***2.05***
Total Xylene							***10,500***	***5.25***		***550***	***0.275***
Total Benzene							***20,000***	***10***		***1000***	***0.5***

ALL OF THEM!

EQUATIONS:		Notes:
e = a x c	for lb/gal	(1) Please provide documentation for how actual (or potential) usage values were calculated
e = a x c / 100	for wt.%	(2) If usage is reported in pounds, VOC/HAP/TAP content must be provided in % by weight; If usage is reported in gallons,
f = e / 2000		VOC/HAP/TAP content must be reported in lb/gallon. Choose b from drop-down menu; d will update accordingly
h = e – (e x (g/100))		(3) Please provide information about capture efficiency and documentation for how control efficiency was
i = h/ 2000		determined. Attach information about retention factors and/or any assumptions made where applicable.
		(4) Use these actual emission numbers to compare to TPERs in MCAPCO Regulation 1.5711.
		(5) For each coating input a, b, c, & g accordingly.

Calculating VOC’s - Spreadsheets

- VOC and Air Toxics from Coatings
- Gasoline Terminals
- Stage 1 Gasoline Dispensing

Questions?

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